AD 41545

INTERM DEVELOPMENT REPORT

FOR

A LINE OF ANTENNA MATCHING TRANSFORMERS

This report covers the period of January, 1954
to March, 1954

Contractor

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ELECTRONICS DIVISIONS

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QUARTERLY REPORT

WG - 69540

Antenna Matching Transformers

Engineering effort during the first quarter of 1954 has all been spent on the Type II unit. The primary side of this transformer connects to a 600 ohm balanced line. The secondary side connects to load impedances of 25 to 225 ohms, with no change in transformer turns ratio. Rated power is 3 KW, 100% modulated. Three transformers have been tested as follows:

A. This transformer had four ferrite cores with a total core area of 1.26 sq. inches. Material was Stackpole Ceramag 2280, which is a nickel zinc ferrite of low permeability. The windings at twenty-four turns total in the primary and six turns in the secondary. Both windings were half on one leg of the core and half on the other, connected in the style known as "Hum-bucking", as shown in Fig. 1. This transformer had reasonable core temperature rise over the frequency range of 2.5 to 7.5 mc, but copper loss was excessive at 7.5 mc. Also it was discovered that the windings were not balanced over this frequency range. Therefore, we rewound this transformer, with a larger number of secondary turns on each leg, and connected the windings in parallel. This required that the secondary turns on one leg be wound in opposite direction to those on the other. Now balance was achieved within much better limits, but winding capacitance increased, so that this transformer did not perform as well with the balanced connection.

That is to say, the temperature rise was still greater at the 7.5 mc end of the frequency range.

B. In order to meet the requirements that the transformer operate into an impedance range of 25 to 225 ohms, we decided next to use a larger core. This seemed advisable because at the higher impedance, higher voltage would be necessary, and the core loss would increase to a prohibitive value unless a larger core was used. The core was of the square shape as shown in Figure I, but the core area was 1.89 sq. inches in the unit designated here as B. The windings were also increased in area to accomodate the lower value of impedance. The transformer had size corresponding to nine KW rather than three because of the range in output impedance values. The transformer was first wound on Ferramic A core material which was believed to be similar in composition to that of transformer A. The windings were wound in balanced fashion but with the secondary split into two windings on each leg. With the primary sandwiched between the two secondary windings, the leakage inductance was reduced, but the capacitance was increased. This transformer performed well at 2.5 mc and has acceptable temperature rise at impedances of 33 and 75 ohms, but not at 200 ohms. At that impedance, the core temperature rise was sufficient to reach the Curie point and demagnetize the core. 33 and 200 ohms were the nearest impedance values to 25 and 225 ohms, respectively, which could be made up from laboratory resistors.

C. A transformer was then made with the same size core and windings as B, but with Ferramic G core material. Ferramic G has approximately the same core loss per cu. in. as A, but has much higher permeability. It was hoped that the tighter coupling would improve the frequency response, but tests indicated that the core temperature rise was still too high at 4.5 mc. It was apparent that the four secondary part-windings did not load up equally and therefore the load was divided between them, see Figure 2. Impedance measurements showed the winding capacitance was greater than had been expected from design calculations.

In an effort to reduce the capacitance of this transformer we removed the outer secondary windings on each leg and again ran the transformer at three load impedances of 33 ohms, 75 ohms and 200 ohms. Performance was substantially the same as before at the two lower impedances, and a longer time was required for the core to overheat. But overheating did occur and caused the core to lose magnetization as in the previous transformer. Calculations showed that very little improvement could be expected from different winding arrangements or combinations of transformers so long as the core material had the same loss and Curie point. There is an approximate relation between the length of wire in the primary winding and the highest frequency at which the transformer must operate. We have exceeded this limit in the larger transformer at 7.5 mc. It therefore appears that transformer A is the best design so far, but there was not

sufficient time to discover the reason for high winding temperature at 7.5 mc. The major advantage to be derived from further work on this transformer lies in the smaller dimensions which result in a higher maximum operating frequency.

Because of the excessive temperature rise on these transformers, no tests were made at 100% modulation. Detailed results for all 3 transformers are given in the following tables. Where 2 values are given for primary current and voltage these values are for each side of the center tap. The differences in value indicate the extent of unbalance.

Ferramic Q cores are now on hand. These cores have about 1/2 the loss of Ferramic A. It is planned to test these cores with fewer turns than transformer A in order to extend the frequency range.

Transformer A with 24/8 turns
not balanced.

	Load (DCR)	Quantity	4.0 to 4.46 MC	8.0MC
Primary	33 ohms	amps	2.41 to 2.55	1.0 to 1.73
		volts	780 + 810	275 + 2300
		VA	3940	3520
		Input Z	641	1888
		(3KVA) Temp. Rise	97 C°	175 C°
	82 ohms	amps	1.70 to 1.75	1.25 to 1.45
		volts	795 + 840	210 + 1850
		VA	2820	2780
		Input Z	948	1526
		(3KVA) Temp. Rise	41 C°	177 C°
	200 ohms	amps	1.37 + 1.45	1.81 + 2.12
		volts	1080 + 1180	175 + 1600
		VA	3190	2980
		Input Z	1605	952
		(3 KVA) Temp. Rise	37 C°	132 C°
	open circuit	amps	0.65 + 0.95	
		volts	1140 + 1270	
		VA	1880	
		Input Z	3090	
	short circuit	amps	4.1 + 4.18	
		volts	685 + 725	
		VA	5840	
		Input Z	341	
Secondary	33 ohms	amps	9.1	6.05
		volts	340	445
		VA	3095	3670
		(3KVA) Temp. Rise	96 C°	160 C°
	82 ohms	amps	5.50	5.85
		volts	500	500
		VA	2750	2925
		(3KVA) Temp. Rise	32 C°	181 C°
	200 ohms	amps	3.55	3.66
		volts	750	680
		VA	2660	2490
		(3KVA) Temp. Rise	35 C°	128 C°
	open circuit	Volts	840	
	short circuit	amps	13.9	
Core	33 ohms (3KVA)	Temp. Rise	45 C°	125 C°
	82 ohms (3KVA)	Temp. Rise	21 C°	103 C°
	200 ohms (3KVA)	Temp. Rise	29 C°	57 C°

Transformer A with 24/6 turns, not balanced.

Temp. Rise measured by thermometer alone
values increased to agree with DCR measurement at 10 MC.

		2.5 MC	4.0 MC	6.0 MC	10 MC	Temp. Rise Measurement changed to DCR - 10 MC
Primary	amps	1.97	2.32	1.7	1.71	1.81
	volts	1555	1235	1570	852	797
44 ohm load	VA	3062	2870	2670	1457	1442
	Input Z	789	532	924	498	440
	(3KVA)Temp.Rise	-		-	-	71 C°
Secondary	amps	8.0	8.0	8.3	8.8	9.7
44 ohm load	volts	382	382	402	382	389
	VA	3050	3050	3336	3360	3770
	Load Z	47.7	47.7	48.4	43.4	40.1
	(3KVA)Temp.Rise	-	-	-	-	-
core-44 ohm load						
	(3KVA)Temp.Rise	85.4	[illegible]	[illegible]	61	61 C°

Transformer A as above rewound so as to improve balance 24/6 turns;
2 sec. in each leg and in parallel.

		2.5 MC	6.2 MC	8.0 MC	10. MC
Primary	amps	2.[illegible]	1.97	2.08	1.21
44 ohm load	volts	14[illegible]	1596	1296	1566
	VA	2814	3140	2695	1896
	Input Z	703.5	810	623.5	1295
	(3KVA)Temp. Rise	167 C°	102 C°	113 C°	1380 C°
Secondary	amps	7.7	7.5	8.0	9.8
44 ohm load	volts	328	407.5	385	315
	VA	2525	3060	3080	3085
	Load Z	42.7	54.4	48.1	32.1
	(3KVA)Temp.Rise	154 C°	101 C°	107 C°	130 C°
Core 44 ohm load.	(3KVA)Temp.Rise	83.5 C°	37 C°	42.5 C°	34 C°

Transformer B L-529401 (Ferramic A core material)		f in MC 2.5 MC	 8.0 MC
Primary 44 ohm load	amps	2.8	4.7
	volts	1031	668
	VA	2880	3140
	Input Z	368	142
(3KVA)	Temp. Rise	110 C°	241 C°
Secondary 44 ohm load	amps	7.8	8.5
	volts	344	379
	VA	2680	3220
(3KVA)	Temp. Rise	80 C°	120 C°
Core 44 ohm load(3KVA)	Temp. Rise	79 C°	199 C°

Similar transformer to above, but tinned copper channels around cores reduced in size:

Primary 44 ohm load	amps		3.55
	volts		788
	VA		2800
	Input Z		222
(3KVA)	Temp.Rise		* 684 C°
Secondary 44ohm load	amps		8.1
	volts		379
	VA		3070
(3KVA)	Temp.Rise		* 5360 °
Core 44 ohm load (3KVA)	Temp. Rise		* 198 C°

* estimated from 20 minutes of operation; was actual temperature of:
- Pri: 180 C°
- Sec: 143 C°
- Core 48 C°

4 (sec) Transformer C f in MC

	Load	Quantity	2.5 MC	4.46 MC	8.0 MC
Primary	33 ohms	amps		2.77	
		volts		515	
		VA		1425 VA	
		Input Z		186 ohms	
		(3KVA) Temp.Rise		53 C°	
	82 ohms	amps	2.40-2.45	2.86-3.02	3.53-3.90
		volts	655 -670	560 -605	383 -420
		VA	3210	3420	2980
		Input Z	546	396	216
		(3KVA) Temp. Rise	54 °C	58 C°	147 C°(91)
	200 ohms	amps		4.1-4.25	
		volts		790 -860	
				1650	
		VA		6900	
		Input Z		394.4	
		(3KVA) Temp. Rise		130 °C	
	open circuit	amps	1.22-2.5	2.75 - 3.0	1.8-1.9
		volts	620-630	618 - 845	155
		VA	2325	4210	2870
		Input Z	985	508	167.5
	short circuit	amps	1.58-1.62	2.95	1.15-1.46
		volts	53.5-55.	280-220	140-165
		VA	173.5	1240	397
		Input Z	67.8	142.2	234
Secondary	33 ohms	amps		9.2	
		volts		335	
		VA		3080	
		(3KVA) Temp. Rise		64 C°	
	82 ohms	amps	5.9	5.9	6.0
		volts	485-500	450-500	390-510
		VA	2905	2810	2700
		Temp. Rise	59 C°	62 C°	178C°(111)
	200 ohms	amps		3.68	
		volts		705-760	
		VA		2690	
		(3KVA) Temp. Rise		2.6 C°	
(Secondary)	open circuit	volts	490-520	525-695	195-250
	short circuit	amps		9.12	
core	33 ohms	(3KVA) Temp. Rise		27 C°	
	82 ohms	(3KVA) Temp. Rise	30.5 C°	35 C°	80 C°
	200 ohms	(3KVA) Temp. Rise		95.5 C° +	

Transformer C

(2 sec)

Load			Quantity	2.5 MC	4.46 MC	8.0 MC
					f in MC	
Primary	33 ohms		amps		2.5 - 2.75	
			volts		670 + 645	
			VA		3450	
			Input Z		501	
		(3KVA)	Temp.Rise		85 C°	
	82 ohms		amps		2.22 - 2.38	
			volts		605 + 630	
			VA		2840	
			Input Z		537	
		(3KVA)	Temp.Rise		84.7 C°	
	200 ohms		amps		2.95 - 3.0	
			volts		770 + 820	
			VA		4730	
			Input Z		535	
		(3KVA)	Temp.Rise		115 C°	
	open circuit		amps		2.14 - 1.98	
			volts		795 + 915	
			VA		3523	
			Input Z		830	
	short circuit		amps		2.275	
			volts		293 + 318	
			VA		1390	
			Input Z		269	
Secondary	33 ohms		amps		9.1	
			volts		330-350	
			VA		3090	
		(3KVA)	Temp.Rise		109 C°	
	82 ohms		amps		5.9	
			volts		460-490	
			VA		2800	
		(3KVA)	Temp.Rise		91 C°	
	200 ohms		amps		3.7	
			volts		715-760	
			VA		2730	
		(3KVA)	Temp.Rise		174 C°	
	open circuit		volts		670-795	
	short circuit		amps		7.125	
Core	33 ohms	(3KVA)	Temp. Rise		54 C°	
	82 ohms	(3KVA)	Temp.Rise		45 C°	
	200 ohms	(3KVA)	Temp.Rise		95.1 C°	

SKETCH SHEET
WESTINGHOUSE FORM 2444 C

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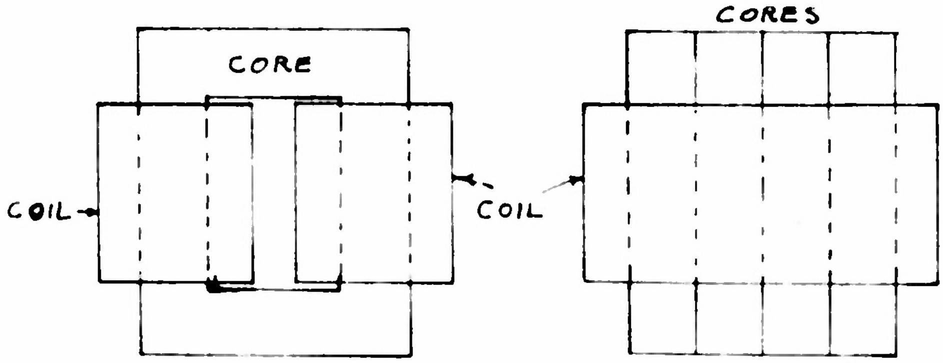

FIG. 1

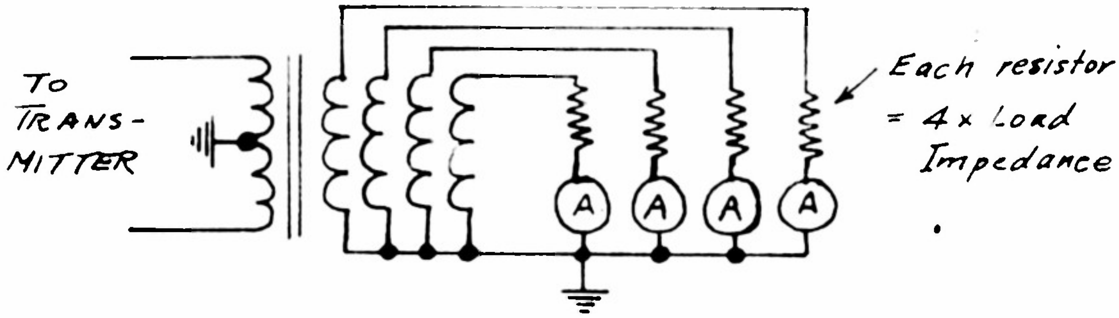

FIGURE 2

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